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13. SUPPLEMENTARY NOTES

14. ABSTRACT

While the initial goal of the proposal was to concentrate on the study of point contact dots to HTSC, our initial measurements showed that surface preparation and impurities will be a major factor in determining the results, especially if we want to study the crossover from Andreev to tunneling behavior. We therefore launched a thorough study of the effects of single impurities and surface modifications on the tunneling spectra in HTSC. Our findings include the understanding of zero-bias anomalies as coming from point-impurities and the transition from spin-gap to superconducting-gap behavior as a function of strength of surface modification.

15. SUBJECT TERMS

Impurities, surface-modifications, zero-bias-anomaly, scanning tunneling microscopy

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FINAL REPORT

to the

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

for a program in

MICROCONTACTS TO HIGH-T_C SUPERCONDUCTORS: A STUDY OF THE CROSSOVER FROM ANDREEV REFLECTION TO A TUNNEL-JUNCTION CHARACTER

for the period June 1, 1997 to May 31, 2000

under

AASERT Grant F49620-97-1-0441

Principal Investigator
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November 2000

Final Report

MICROCONTACTS TO HIGH-T_C SUPERCONDUCTORS: A STUDY OF THE CROSSOVER FROM ANDREEV REFLECTION TO A TUNNEL-JUNCTION CHARACTER

June 1, 1997 to May 31, 2000

Objectives:

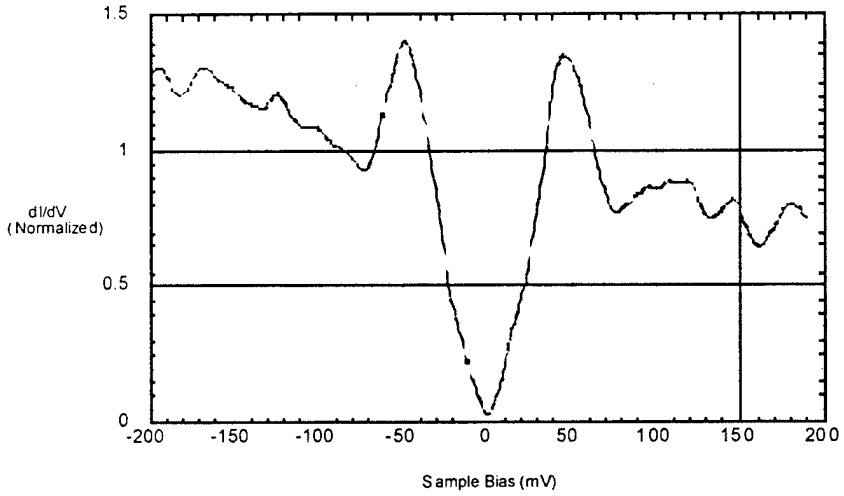
We proposed to study thoroughly point contact measurements from normal metal dots to HTSC. In particular we proposed to concentrate on the crossover between Andreev reflection and normal-superconductor tunneling. The main purpose of this study is to lay the foundation for better design possibilities of the resistance in SNS junctions which are the building blocks of currently used SQUIDs that are made of HTSC.

Statement of Effort:

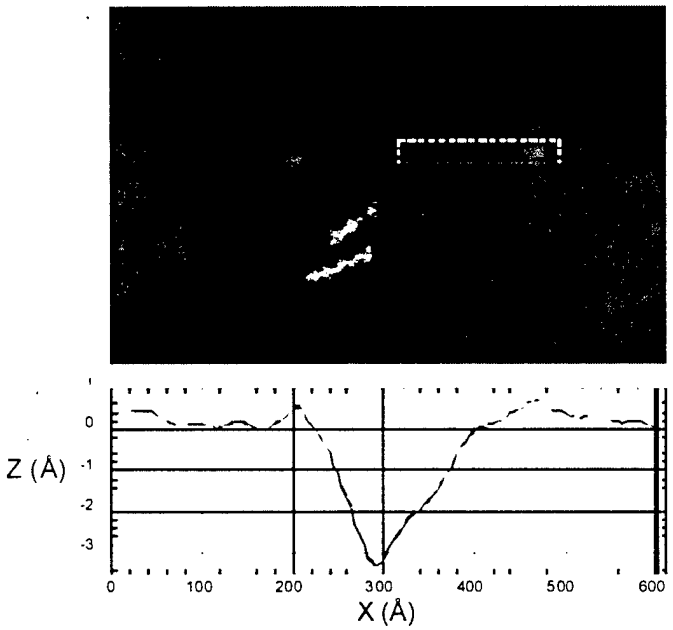
In the past year we continued the study of impurities in high-Tc superconductors. Following our low-temperature STM studies of impurity states on the surface of BSCCO, we continued this study by using the STM to introduce other controlled modifications to the surface.

Experiment performed with a low temperature UHV STM. Base temperature was 6 K. Vacuum: $<10^{-9}$ Torr at room temperature. STM tip was made of Au and was cleaned by field emission and crashing on Au film. BSCCO samples were cleaved in vacuum, presumably exposing BiO surface. Images typically taken at -200 mV, 100 pA conditions. Typical unmodified surface is shown below:

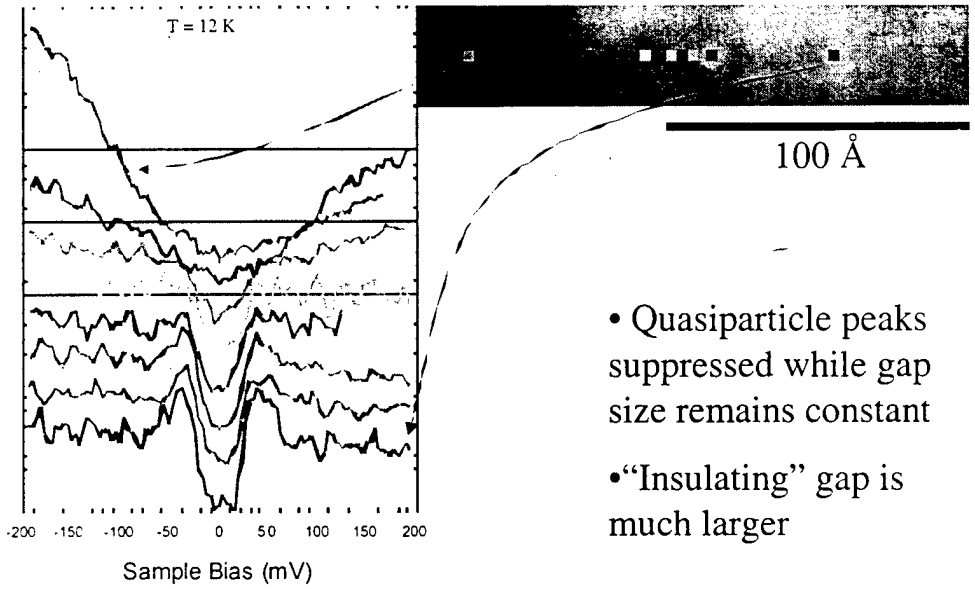
Typical native surface spectrum is shown below:



To modify the surface we note that BSCCO is very sensitive to excessive current or voltage. We therefore increase the Tunnel current to 500 pA at –200 mV sample bias and scan the tip over a 140 Å x 90 Å area. A typical modified region is shown below:



A summary of our results is presented in the figure below:



This striking result shows that surface modification causes pseudogap-like behavior between the insulating and superconducting states at low temperature, and that gap size indicates that this surface modification is not completely equivalent to doping.

Accomplishments/New Findings:

1. Au impurities are strong scatterers on BSCCO and spectroscopy shows zero-bias anomaly with a split peak.

2. Oxygen manipulation on the surface of BSCCO transforms the surface into the "underdoped regime." Spectroscopy of the manipulated surface shows the evolution from a pseudo-gap to a full superconducting gap.

Personnel Supported:

Craig Howald (graduate student)
Lada Adamic (summer quarter graduate student) second year of contract.

Publications:

1. Ali Yazdani, C.M. Howald, C.P. Lutz, A. Kapitulnik, and D.M. Eigler, "Impurity-Induced Bound Excitations on the Surface of $Bi_2Sr_2CaCu_2O_8$," *Phys. Rev. Lett.* **83**, 176 (1999).

2. Craig M. Howald and Aharon Kapitulnik, "Surface Modification and Gap Structure in BSCCO," preprint, 2000.

Interactive Transitions

Conferences:

Professor Kapitulnik and Craig Howald both attended the American Physical Society Meeting, March 1998, Los Angeles, CA.

American Physical Society 1999 Centennial Conference, Atlanta, GA

Consulting: None

Transitions: None

New discoveries, inventions, or patent disclosures:

None

Honors/Awards:

None